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A Green Approach to Synthesize the Zinc Oxide Nanoparticles using Aqueous Extracts of *Ficus benghalensis* L.

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ABSTRACT
We report a green approach to synthesize Zinc oxide nanoparticles (ZnO NPs) utilizing the bio components of leaves, stem, root, aerial root, fruits, and fresh and dried bark extracts of *Ficus benghalensis* in this study. Zinc oxide nanoparticles have fascinated intense research interest because of its significant applications in the field of electronics, spintronics, piezoelectricity and medicine. Zinc nanoparticles were characterized using UV-Visible Spectroscopic method. The nanoparticle suspension showed maximum UV-Vis absorbance peak in between 290 nm to 300 nm which indicates formation of Zinc oxide nanoparticles.

Key words: Zinc oxide nanoparticles, *Ficus benghalensis* L. green synthesis, characterization.

INTRODUCTION

Modern technology is aiming to use the plant extracts as reducing as well as capping agent for the synthesis of nanoparticles without leaving toxicity to the surrounding environment. All most all types organisms have been tested to synthesize biologically mediated nanoparticles which are nonhazardous in nature.

Zinc oxide (ZnO) is a distinctive electronic and photonic wurtzite n-type semiconductor which has a wide direct band gap of 3.37 eV and a high exciton binding energy (60meV) at room temperature, which overcomes the use of various semiconducting materials [1]. Zinc oxide nanoparticles play an important role in drug delivery, sunscreens, agriculture, disinfectant, water and air purification, solar and fuel cells etc. [2].

Many reports are available for the biosynthesis of Zinc oxide nano particles (ZnO NPs) from plant extracts. For example ZnO NPs have been synthesized using *Acalypha indica* [3], *Passiflora foetida* [4], *Morinda pubescens* [5], *Aloe vera* [6], *Calotropis procera* [7] etc.

Ficus benghalensis L. (family Moraceae) is also known as *Ficus indica* (Indian banyan tree). Its life use to start as an epiphyte. This keystone species provides desirable shelters to many birds and animals. It is a very large, evergreen tree grows up to 30meters with many spreading branches and aerial roots. It is a member of four sacred trees (Ksirvriksas), distributed all over India and used to be planted to conserve soil [8].

Ayurveda reveals its usefulness to mankind since ancient time. Whole plant is used in traditional systems of medicines in India to cure various disorders like ulcers, leprosy, syphilis, diabetes, biliousness, dysentery, skin diseases, inflammation etc. Its milky latex is reported to possess aphrodisiac properties [9].

Silver and gold nanoparticles were synthesized with help of leaf extract of the *Ficus benghalensis* [10, 11, 12]. Recently, the synthesis of Zinc oxide nanoparticles has attracted the interest of researchers, because of its various applications and its cost effective method of synthesis. This is the first report for the biosynthesis of Zinc oxide nanoparticles using aqueous extracts of various parts of *Ficus benghalensis*.

MATERIALS AND METHODS

Ficus benghalensis is an economically and religiously valuable tree species in India. All the plant parts (leaves, stem, root, aerial root, fruits, and fresh and dried bark) were collected from a single tree, which was habited in the coastal area of Pondicherry, India. The trees were identified with the help of "The flora of Presidency of Madras" [13].

The plant parts namely fresh and green leaves, stem, root, aerial root, fruits, fresh bark and dried bark were collected to synthesize ZnO nanoparticles. All the parts were washed thoroughly with tap water followed by distilled water to remove dust and finely chopped into small pieces (Figs. 1-7 A-B).

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The plant extracts were prepared by following the procedure described by Shekhawat et al, [14]. The collected plant materials were weighed about 5gm and first cleaned with distilled water and then boiled in 50ml distilled water in a 250ml Erlenmeyer flask. The final broth solutions were filtered and stored at 4^{o}C in a refrigerator.

1mM aqueous solution of Zinc nitrate hexahydrate ($Zn(NO_3)_2.6H_2O$) (Merck, Mumbai, India) was prepared for synthesis of ZnO nanoparticles. For the synthesis of ZnO NPs, three boiling tubes were taken, one containing 10 ml of 1mM $ZnNO_3$ solution as control and the second containing 10ml plant broth and the third one contains 9 ml of 1mM Zinc nitrate solution and 1ml of plant leaf extracts as test solution (Figs. 1-7C)

These were incubated at room temperature for 1-2 hours. The color change of the broth test solutions were checked periodically and the ZnO NPs were characterized qualitatively by UV-Visible spectrophotometer (Systronics Double Beam Spectrophotometer (Model 2202, Systronics Ltd. India). The UV-Vis absorption spectra of the zinc colloids were recorded by using wave length scan between 200nm and 700nm.

RESULTS AND DISCUSSION

Ficus benghalensis is said to be a holistic tree which possesses antiatherogenic, anthelmintic, antitumor, analgesic, antipyretic, antidiabetic and ameliorative, hypoglycemic, antidiarrhoeal, hypolipidemic, immunomodulatory and wound healing properties [15,16,17,18,19,20,21,22,23]. Some important Ayurvedic formulations from *F. bengalensis* are available in the market, such as Nyagrodhaadi churnam (Bhaishajya Ratnavali), Saarivaadyaasava, Chandanaasava, Dineshavalyaadi Taila (Sahasrayoga) etc.

Biogenesis of nanoparticles could be exploited to derive herbal drugs, and many researchers have tried their antimicrobial activities against various human pathogens which have been successfully proved [14,5].

Biogenesis of Zinc oxide nanoparticles from leaves, stem, root, aerial root, fruits, and fresh and dried bark extracts of *Ficus benghalensis* was investigated for the first time. ZnO nanoparticles were synthesized using plant extracts under ambient conditions in the present study. The colour change was not so impressive to find the formation of ZnO colloids in the test solutions. The ZnO NPs synthesize by this approach are quite stable and no visible changes were observed even after four weeks of time. Surfactant seems to play an important role in determining the size of the ZnO nanoparticles (Figs. 1-7C).

F. benghalensis is known to contain valuable phytochemicals like quercetin-3-galactoside, rutin, friedelin, taraxosterol, lupeol, β-amyrin along with psoralen, bergapten and β-sisterol, rhamnoside [15,8]. Its bark is reported to have Leucodelphinidin derivative, bengalenoside (Aglucoside), Leucopelargonin derivative, leucocynidin derivative, glycoside of leucopelargonidin [24,25]. It can be proved that banyan is an active ingredient in fairness creams and cosmetics due to these properties.

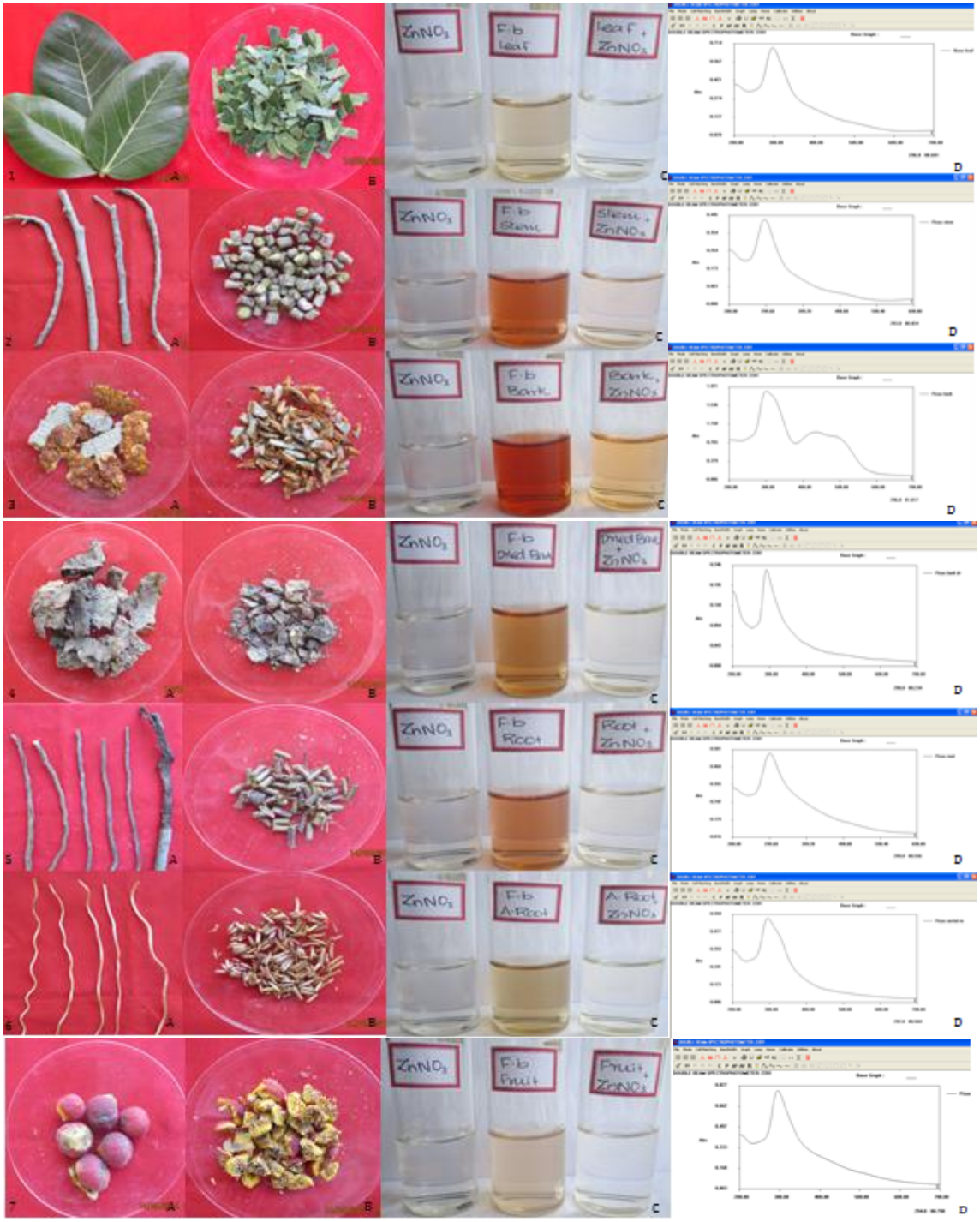
The size of the nanoparticles drastically decreases in the presence of the natural extracts/surfactants. It is well known that ZnO is a polar crystal, Zn^{2+} lies within a tetrahedral group of four oxygen ions. Zinc and oxygen atoms are a tetrahedral group of four oxygen ions. Zinc and oxygen atoms are arranged alternatively and the top surfaces are Zn terminated while the bottom surfaces are oxygen terminated. The plant extracts were worked as reducing as well as capping agents for the synthesis of zinc colloids. During the synthesis process, surfactants tend to adsorb on the active sites of ZnO nuclei and leads to the formation of ZnO nanoparticles [26].

Synthesis of nanoparticles from the different parts the same plant were also reported in *Couroupita guianensis*, *Morinda pubescens*, *Passiflora foetida* by Shekhawat et al, [14,5,4].

The formation of Zinc oxide nanoparticles by the reduction of aqueous solution of *Ficus benghalensis* plant parts were confirmed by the UV- Visible spectroscopic analysis. The optical properties of ZnO NPs from the plant extracts of *F. bengalensis* were characterized by the UV-Vis spectrophotometer at room temperature.

The spectroscopic result reveals that, water soluble surfactants present in *Ficus benghalensis* plant extracts were responsible for the reduction and the stabilization of zinc oxide nanoparticles. These soluble elements could have acted as reducing and stabilizing agents preventing the aggregation of nanoparticles in solution and extracellular biological synthesis of zinc oxide nanoparticles.

The zinc oxide nanoparticles synthesized using the aqueous extract of leaf showed the absorption peak at 296nm, stem extract at 293nm, bark extract at 296, dried bark extract at 290nm, root extract at 299nm, aerial root extract at 292nm and the fruit extract



Figs. 1to 8: Different parts of *Ficus benghalensis*used for biosynthesis of ZnO nanoparticles and UV-Vis spectral analysis of Zinc oxide nanoparticles. 1(A to C) Leaves and the reaction mixtures, (D) UV-Vis spectral absorbance peak with leaf extract. 2(A to C) Stem segments and the reaction mixtures, (D) UV-Vis spectral absorbance peak with stem extract. 3(A to C) Fresh bark and the reaction mixtures, (D) UV-Vis spectral absorbance peak with fresh bark extract. 4(A to C) Dried bark and the reaction mixtures, (D) UV-Vis spectral absorbance peak with dried bark extract. 5(A to C) Roots and the reaction mixtures, (D) UV-Vis spectral absorbance peak with root extract. 6(A to C) Aerial roots and the reaction mixtures, (D) UV-Vis spectral absorbance peak with aerial root extract. 7(A to C) Fruits and the reaction mixtures, (D) UV-Vis spectral absorbance peak with fruit extract.

shown the absorption peak at 294nm due to its surface Plasmon Resonance (Fig 1-7D).

These results confirmed that the zinc oxide nanoparticles have been synthesized in the reaction mixture of zinc nitrate and plant broth. Tripathi et al, [10,11] synthesized silver ((Ag NPs) and gold

nanoparticles (Au NPs) from the leaf extract of *Ficus benghalensis* and studied their antibacterial activity against *Escherichia coli*. These nanoparticles were characterized with the help of UV-Visible spectroscopy and Dynamic light scattering methods. Francis et al, [12] have also reported synthesis of gold nano particles from the leaf extracts of *F. benghalensis*. These Au NPs are active against gram positive and negative bacteria.

CONCLUSION

The biological synthesis of zinc nanoparticles using extracts of different parts of *Ficus benghalensis* provides a faster, economical and greener method. It is an ecofriendly procedure since this avoids multiple reaction steps conventional energy sources and harmful chemicals. Zinc nanoparticles can exist in ions only in the presence of strong oxidizing substances. The chemical compounds, flavonoids, terpenoids and other constituents present in *Ficus benghalensis* extracts were the surface dynamic molecules which stabilized the nanoparticles. Spectroscopic results are indicative of successful synthesis of ZnO nanoparticles. The synthesized nanoparticles can be directly used in the field of agricultural, engineering, biomedicals, etc.

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